U.S. Army Medical Department Center and School

Nuclear Biological Chemical Sciences Branch

# Low Level Radiological Threats

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# Low Level Radiological Threats

## World Trade Center
## September 11, 2001

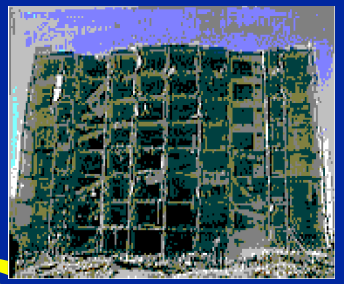
**C** hemical agents

**B** iological agents

**R** adiological agents

**N** uclear devices

**E** xplosive devices

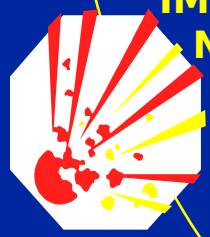


# Low Level Radiological Threats

## Potential Probability vs. Impact

NUCLEAR WEAPON

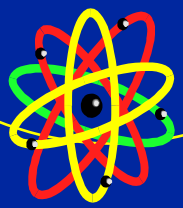
BIOLOGICAL AGENT



IMPROVISED NUCLEAR DEVICE

CHEMICAL AGENT OR TOXIC INDUSTRIAL CHEMICAL

RADIOACTIVE MATERIAL

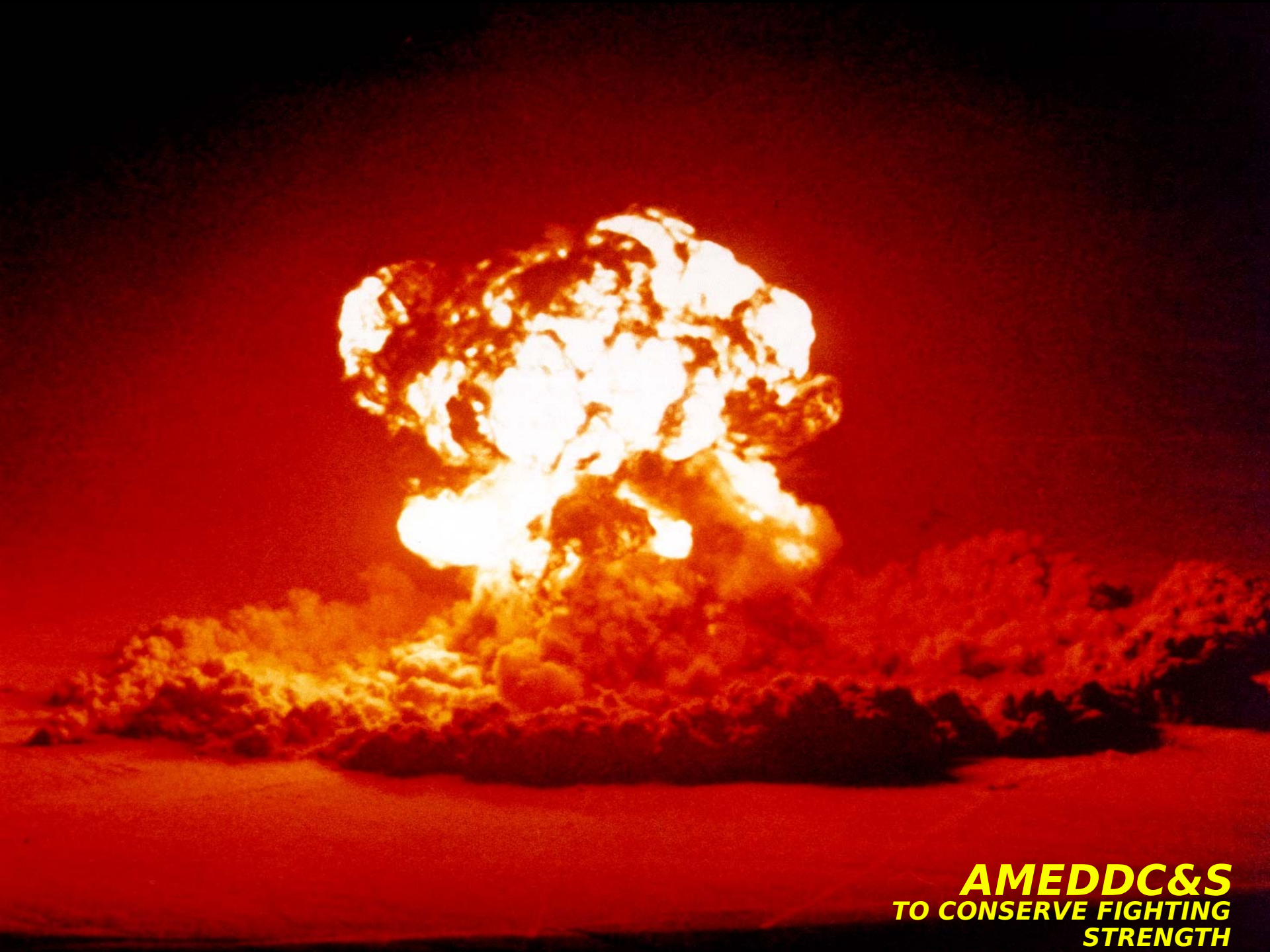


POTENTIAL IMPACT

PROBABILITY/LIKELIHOOD

# Radiological Weapons

## *A Unique Terrorist Threat*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# Low Level Radiological Threats

# Radiological Weapon History

- 1946 “Baker” test produced massive contamination
  - Renewed interest in radiological weapons
- Later testing accidents confirmed the potential of radiological weapons

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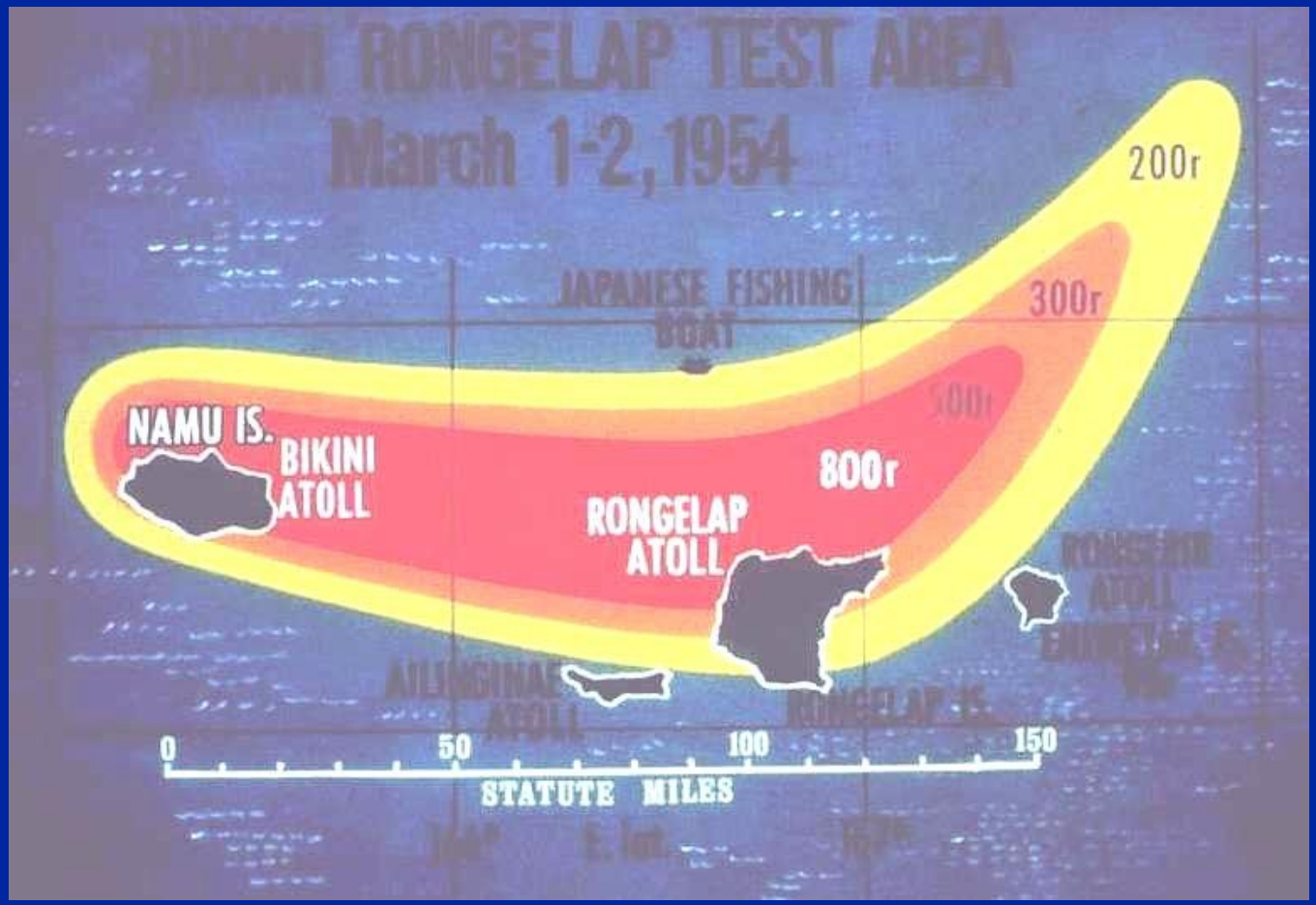
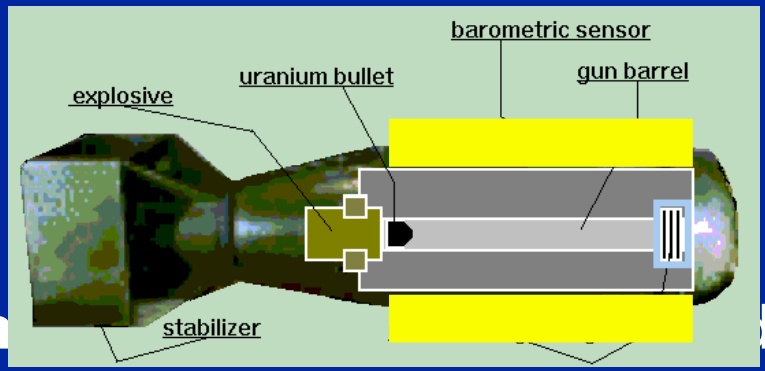
# The Marshall



# Radiological Weapon History

- The US established a radiological laboratory at the Dugway Proving Ground
  - Series of radiological bomb tests
- Cobalt bomb envisioned, possibly tested by the British




- 1950: General Ma ding China-Korea order

# Radiological Weapon History

- By 1952, US concluded radiological weapons were not militarily effective
- Throughout the cold-war, the US assessed the Soviet radiological threat as minimal
- Other countries considered the weapons:
  - 1963: Egypt threatens to put Co-60 on missile warheads aimed at Israel
  - Iraq conducted 3 radiological bomb tests immediately before the Gulf War
  - 1999: Concerns in the Balkans



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# Malicious Uses of Radioactive Sources

- Pranks
  - Locks, clothes and butterflies contaminated by US nuclear workers
- Extortion attempt with enriched uranium
- Poisonings
- MIT, NIH, Brown University

*To prompt an abortion!*

# Malicious Uses of Radioactive Sources

- Soviet commits suicide with Cs-137
- American castrated his son with a well-logging source
- CIA assessed the possibility a foreign leader was assassinated by the Soviets with radiation and/or radioactive materials
- 1994 assassination of Moscow

**Accidents Experiences Support Concerns**

# 1,375 Ci Cs-137 Goiania 1987

- Two men took a teletherapy machine from an abandoned medical clinic
- They opened the source and found a luminous blue powder
- They rubbed the powder on his arm, one gave some to his 6 year old daughter, they shared the powder with families and friends
- 112,000 persons monitored, 129 contaminated
- 85 houses contaminated.



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# Goiania 1987

- Injuries:
  - Four deaths
  - 16 survived the ARS
  - 20 localized injuries, one person's arm amputated

# 450 Ci Co-60 uarez 1983

- Teletherapy dismantled, puncturing the source (6,000 metal pellets)
- Moved by truck to a scrap metal yard.
- 800 to 1000 pellets spilled onto truck bed
- Truck parked on a city street for 40 days with radiation levels = 1000 R/hr
- Source added to scrap metal



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# Juarez 1983

- Five weeks later, truck with radioactive rebar got lost in New Mexico
- Passed a radiation detector at the Los Alamos National Laboratory, accident discovered
- No deaths, 4,000 people exposed, 814 buildings contaminated

# Mexico 1962

- A ten-year old boy found a 5 Ci Co-60 source and took the source home
- Source remained in his house for 4 months
- The boy, his pregnant mother, three-year-old sister and grandmother died
- Father survived ARS

**5 Ci Co-60**

# Morocco 1984 — 30 Ci Ir-192

- A laborer found a detached radiographic source and took it home
- Laborer and his entire family (7 other people) died within 2 months
- Physicians repeatedly misdiagnosed illnesses

**Demonstrated the importance of notifying medical authorities!**



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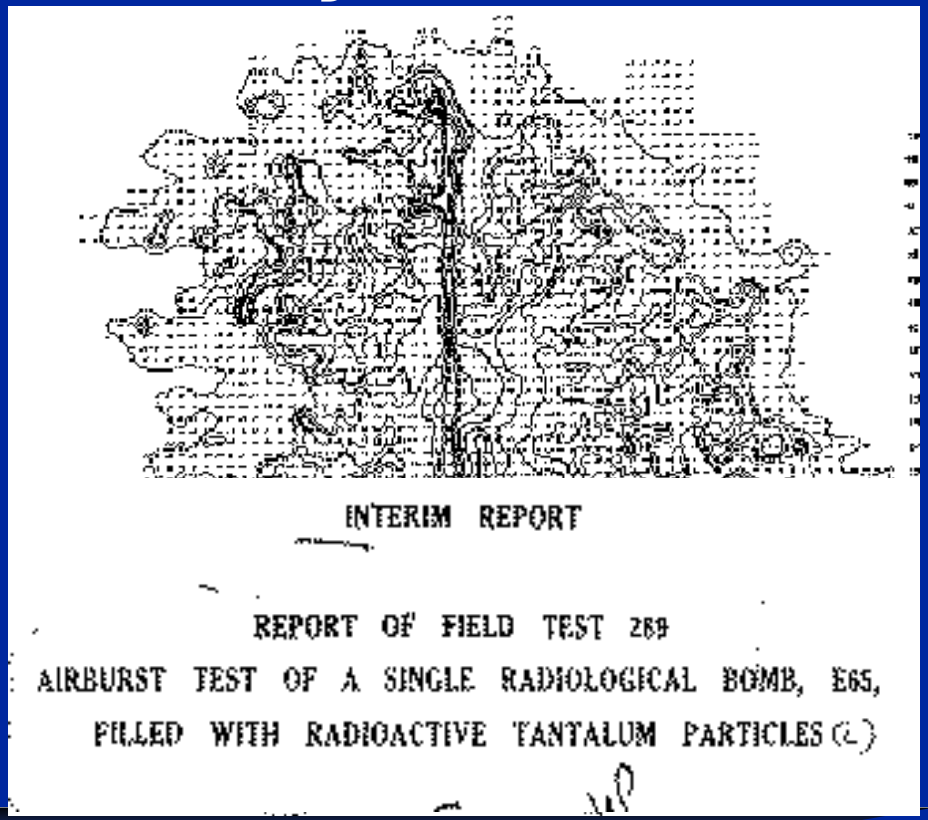
# Potential Threat

- Radiological Weapon
  - Military radiological weapons
  - Criticality devices
  - Radiological Dispersal Devices (RDDs)
  - Improvised Radiological Devices (IRDs)
- Non-weapon
  - Accidental
  - Environmental

# Military Radiological Weapons

- Not militarily effective



INTERIM REPORT

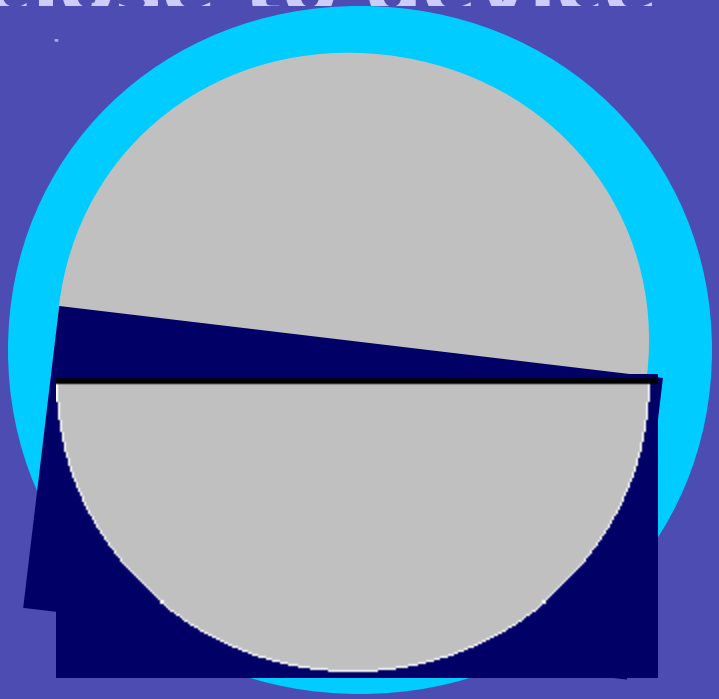
REPORT OF FIELD TEST 269

AIRBURST TEST OF A SINGLE RADIOLOGICAL BOMB, E65,

FILLED WITH RADIOACTIVE TANTALUM PARTICLES (U)

# Criticality Devices

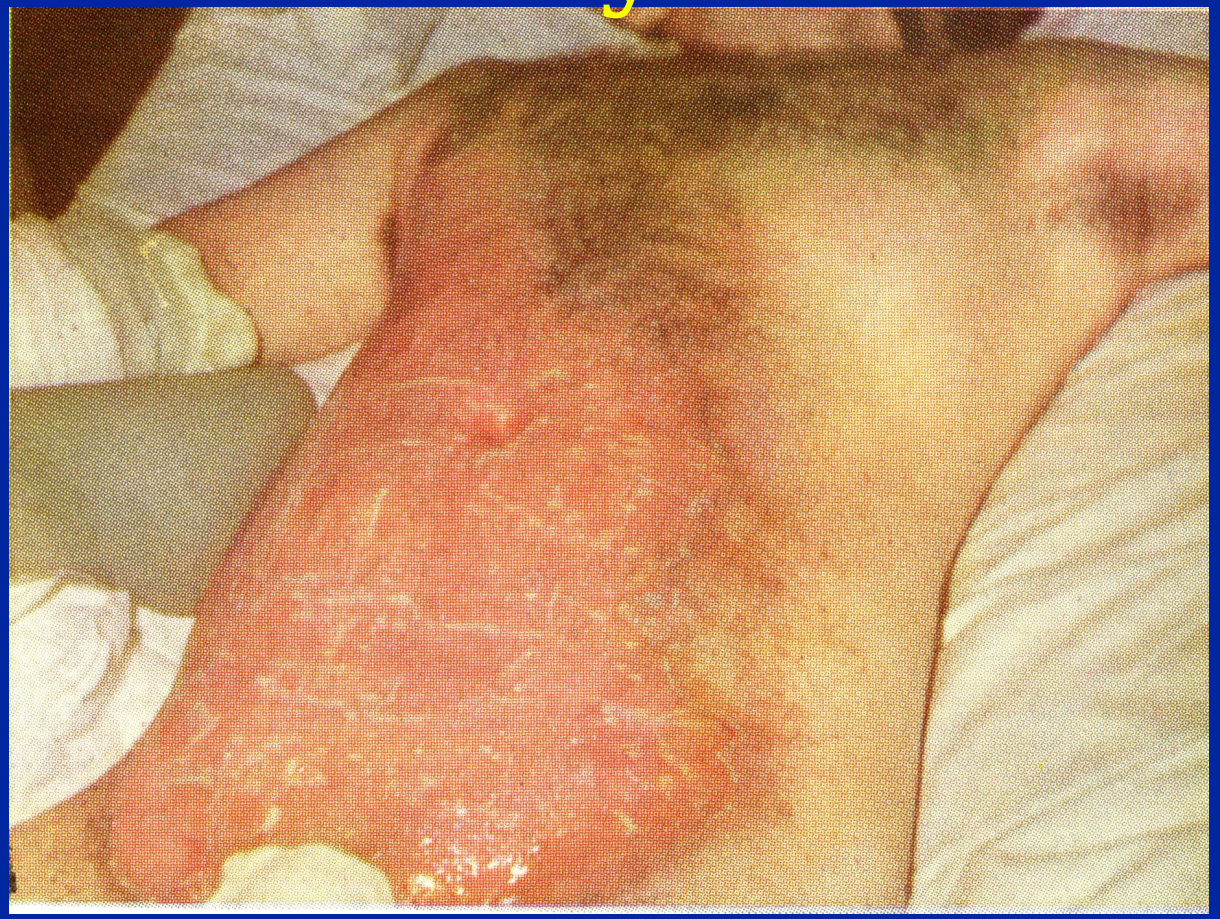
- Short-term lethal dose for persons very close to device
- Most critical systems quick disassemble themselves



# Criticality Devices

- Short-term lethal dose for persons very close to device
- Most critical systems quickly disassemble themselves
- Stability can be maintained

# Criticality Devices



Soft (Low Energy) X-ray 840 REM & Gamma ray exposure of 500 REM.

# Criticality Devices

Hands and arms (especially the right) received several thousand REM.

# Criticality Devices

Soft (Low Energy) X-ray 840 REM & Gamma ray exposure of 500 REM. Dorsal view of right hand 9 days after exposure

# Criticality Devices

Soft (Low Energy) X-ray 840 REM & Gamma ray exposure of 500 REM. Dorsal view of left hand on day before death (24 days after exposure)

# Radiological Dispersal Devices (RDDs)

- The “classic” radiological device
- Defined by DOD as “…any device, including any weapon or equipment, other than a nuclear device, specifically designed to employ radioactive material by disseminating it to cause destruction, damaged, or injury…”

# Radiological Dispersal Devices (RDDs)

- Terrorism could explosively disperse radioactive materials
- World Trade Center bomb was seeded with cyanide
- Assessments of impact:
  - Few deaths or serious injuries
  - Widespread contamination
  - Large numbers of low-level exposures

# Improvised Radiological Devices (IRDs)

- Any weapon improvised from a radioactive source originally constructed for another use (such as medical, industrial, educational or research)
- IRDs include all attack modalities
- IRDs involve sources ranging from insignificant to large

# Availability of Sources

- Sources found in
  - Medical Facilities
  - Industrial Facilities
  - Academic/Research Facilities
  - Other uses & locations
- Found in all countries
  - Industrialized
  - Least Developed Countries



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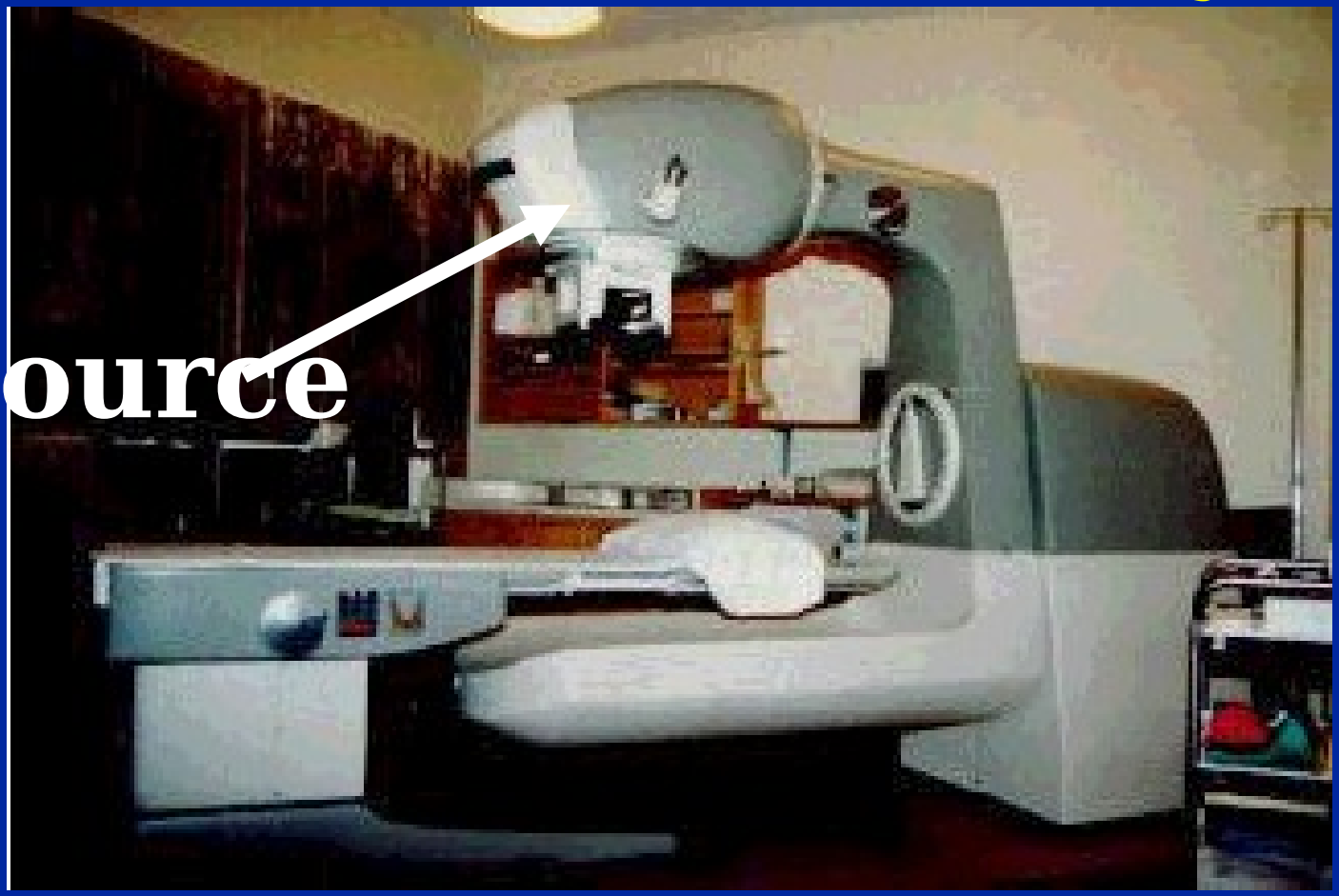
# Medical Facilities

# Medical Teletherapy



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# Brachytherapy Sources

- Needles and Carrying Case

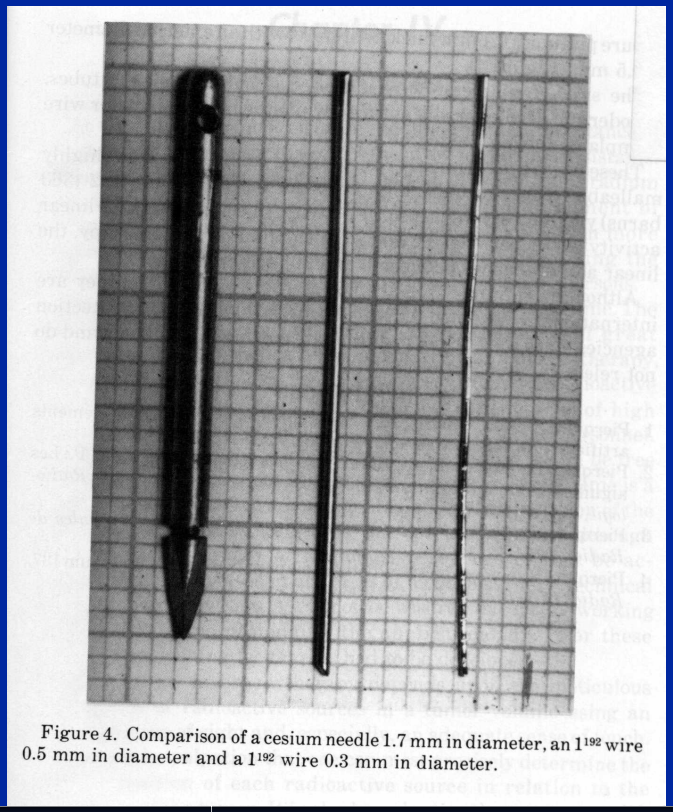

Figure 4. Comparison of a cesium needle 1.7 mm in diameter, an $I^{192}$ wire 0.5 mm in diameter and a $I^{192}$ wire 0.3 mm in diameter.

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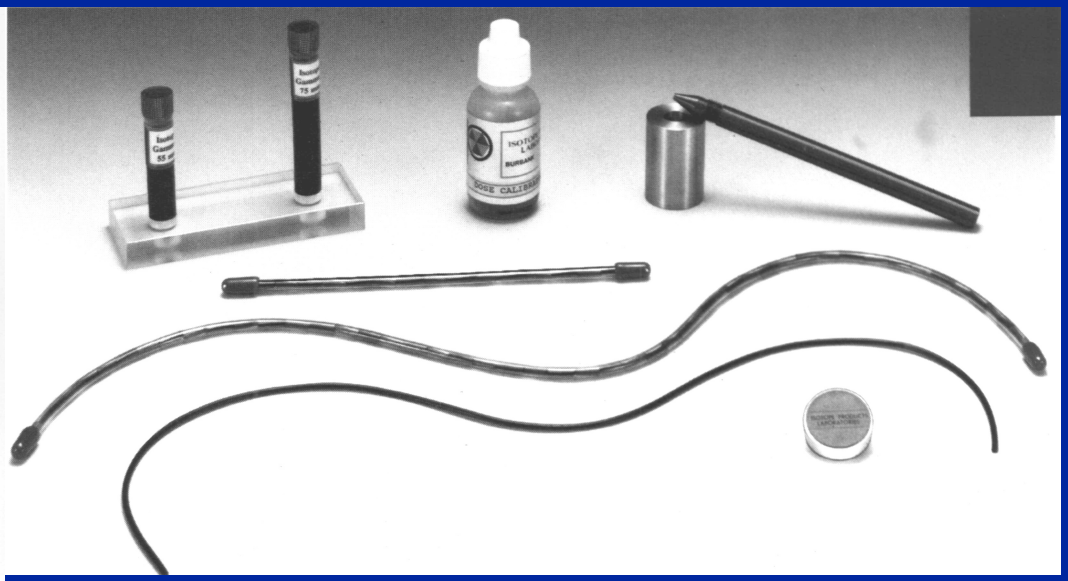
# Medical Reference Sources

- Locations of use: Medical facilities performing nuclear medicine





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# Gamma Irradiators

- To sterilize equipment

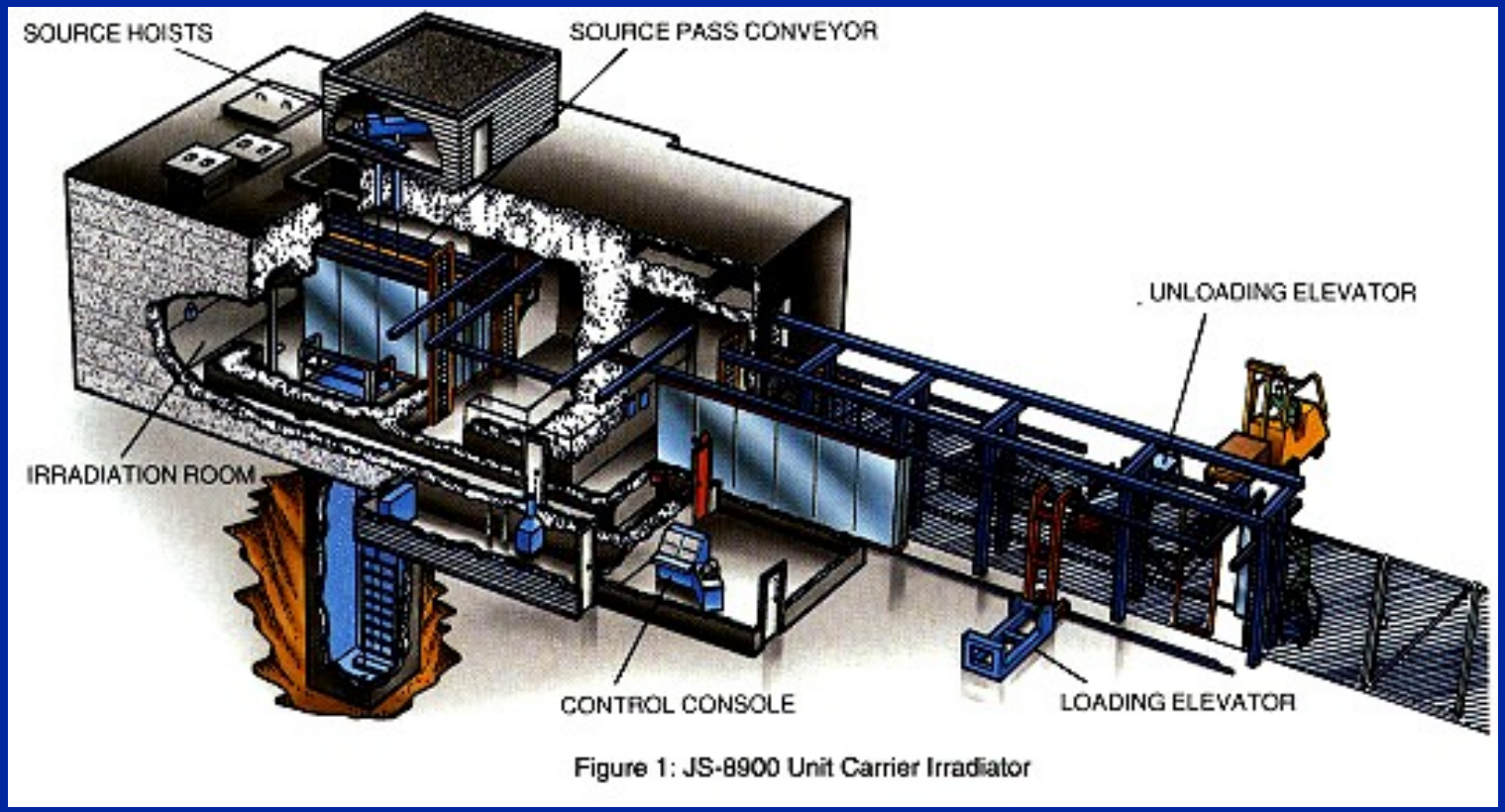


Figure 1: JS-8900 Unit Carrier Irradiator



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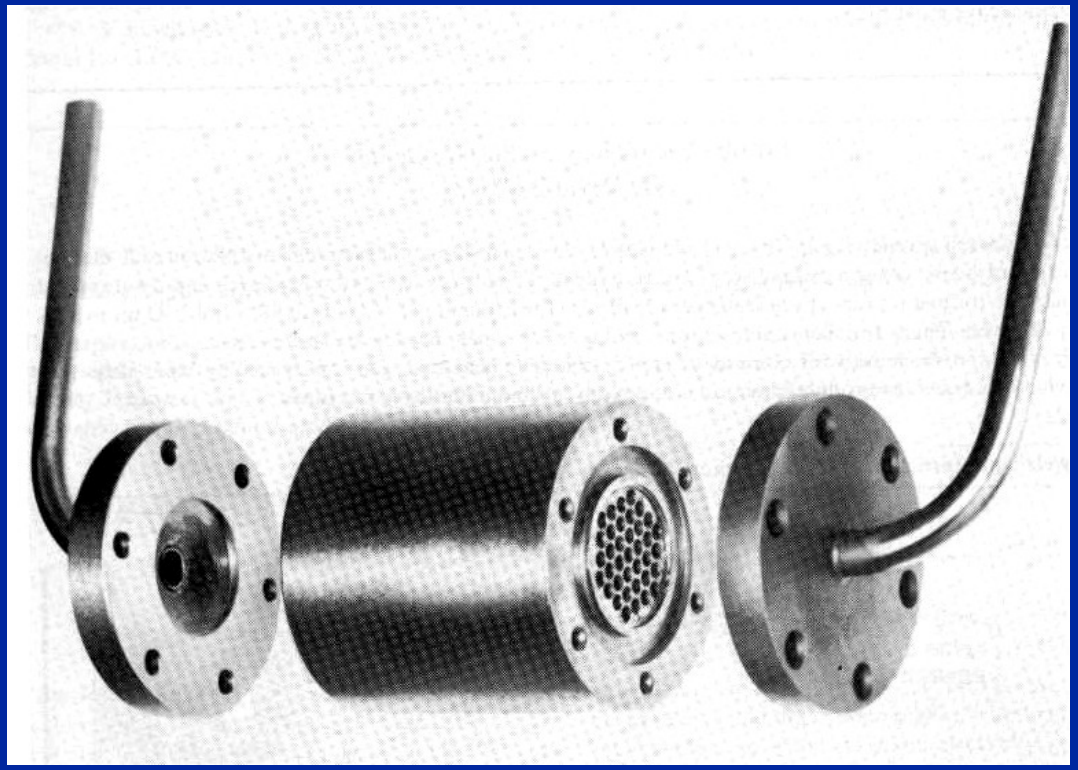
# Beta Irradiators

- Blood Irradiator





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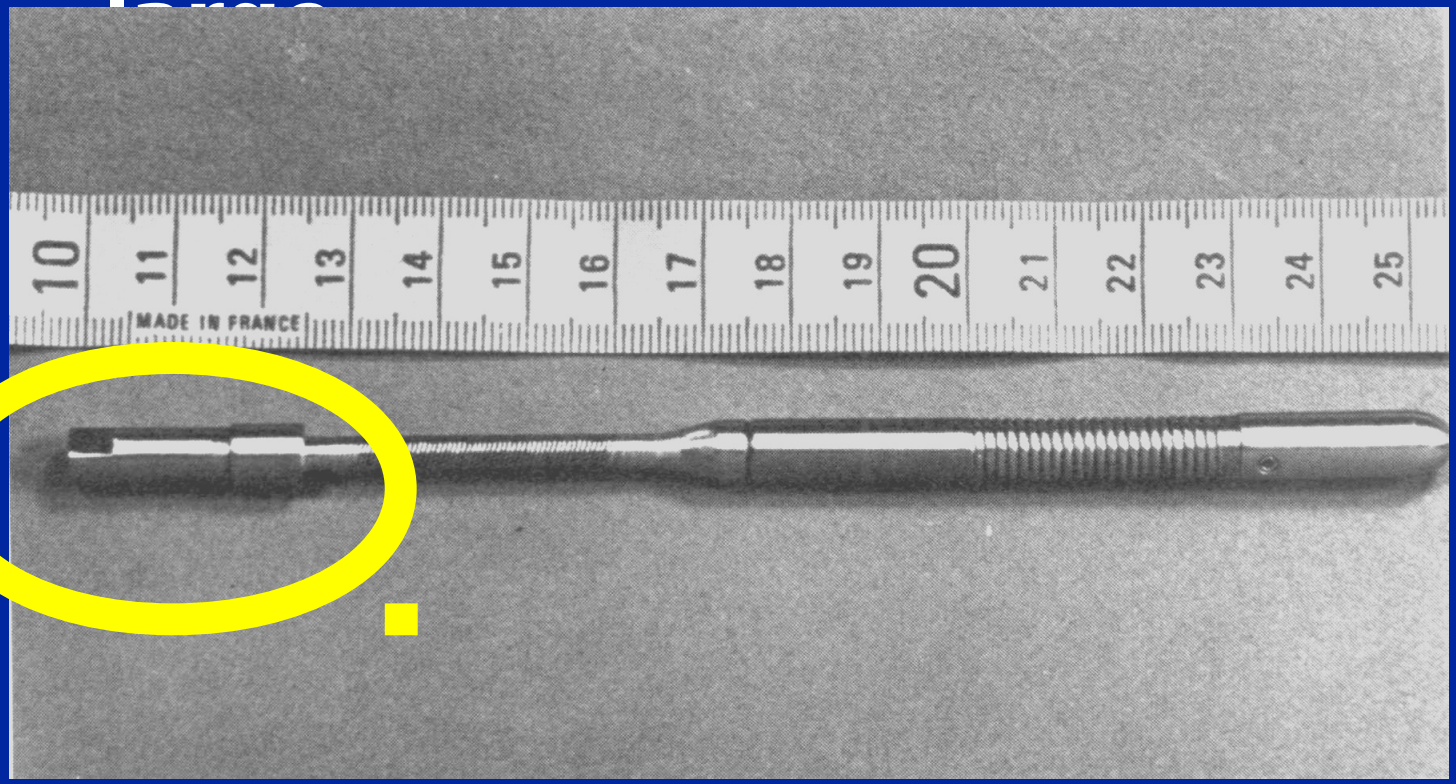
# Industrial Facilities

# Industrial Radiography

- High activity gamma sources in “gamma cameras”

# Industrial Radiography

- Physically small, radiologically large



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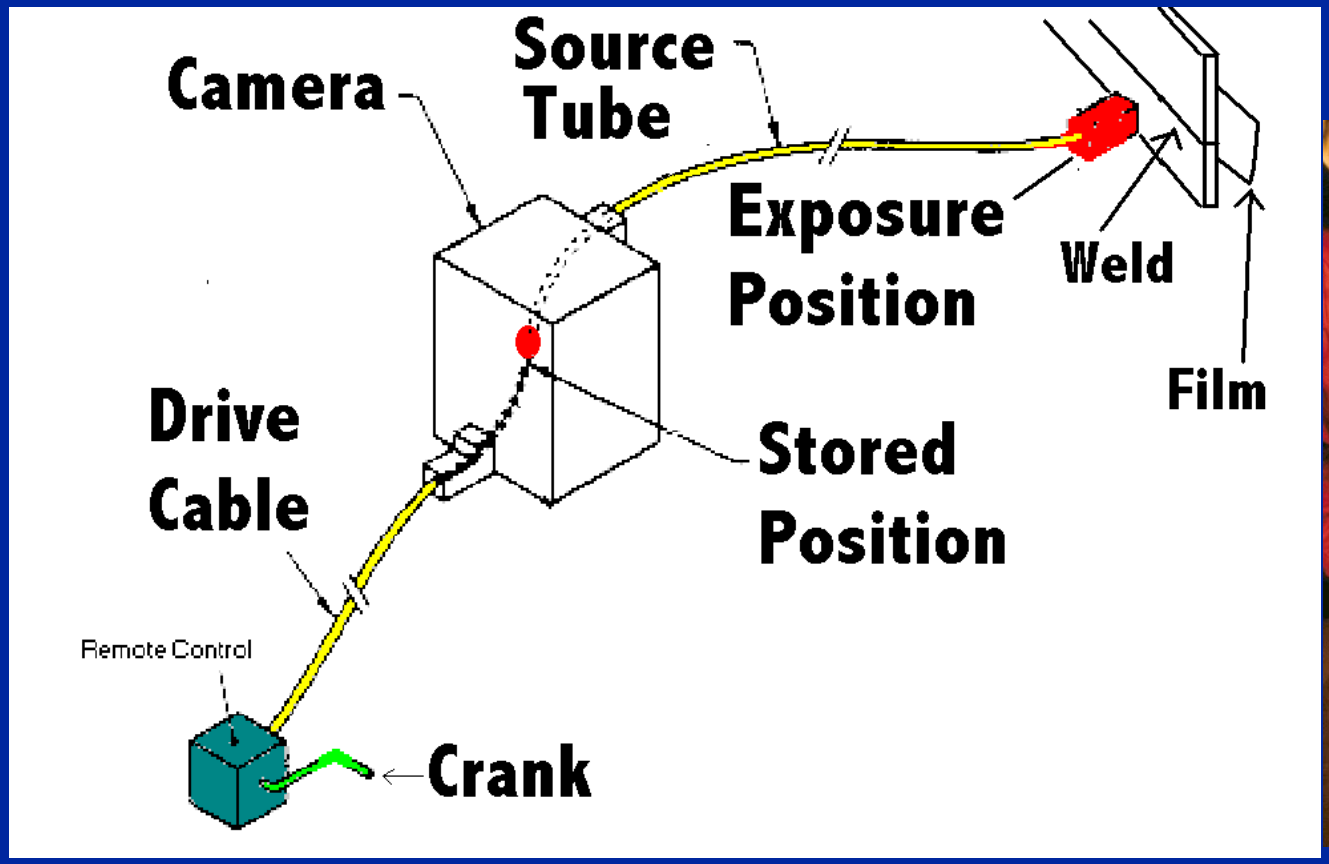
# Low Level Radiological Threats



# Moisture Density Gauges

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# Well Logging

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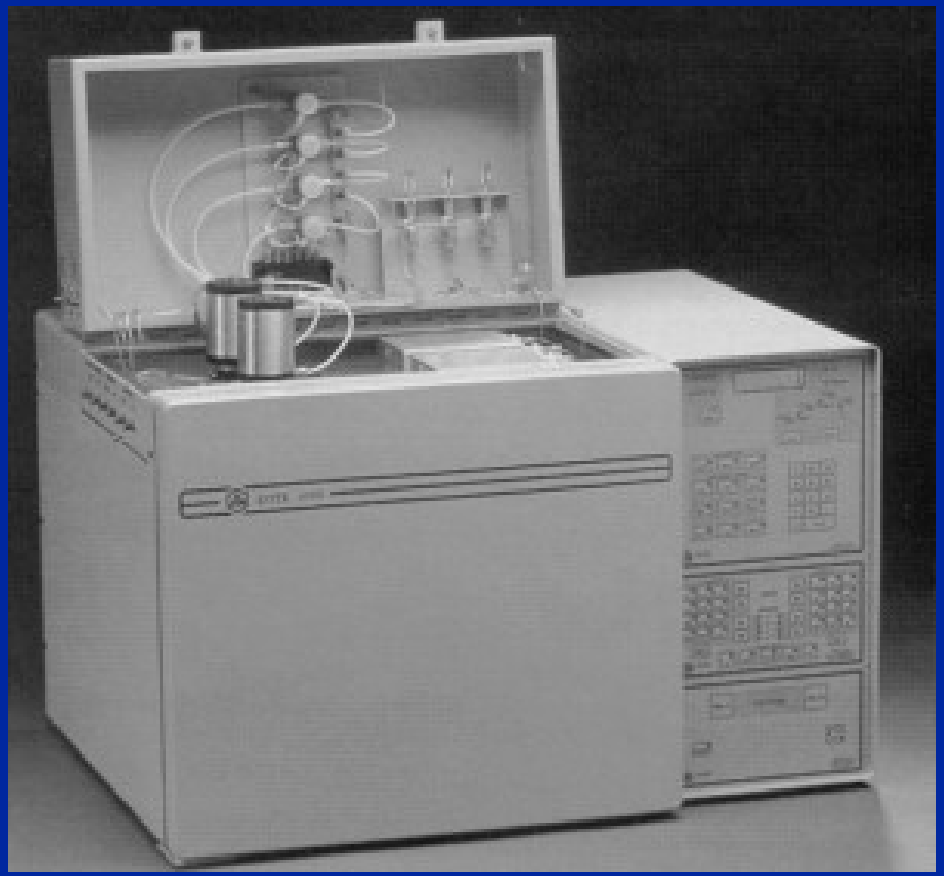
# Academic and Research Facilities

# Chromatography Detectors





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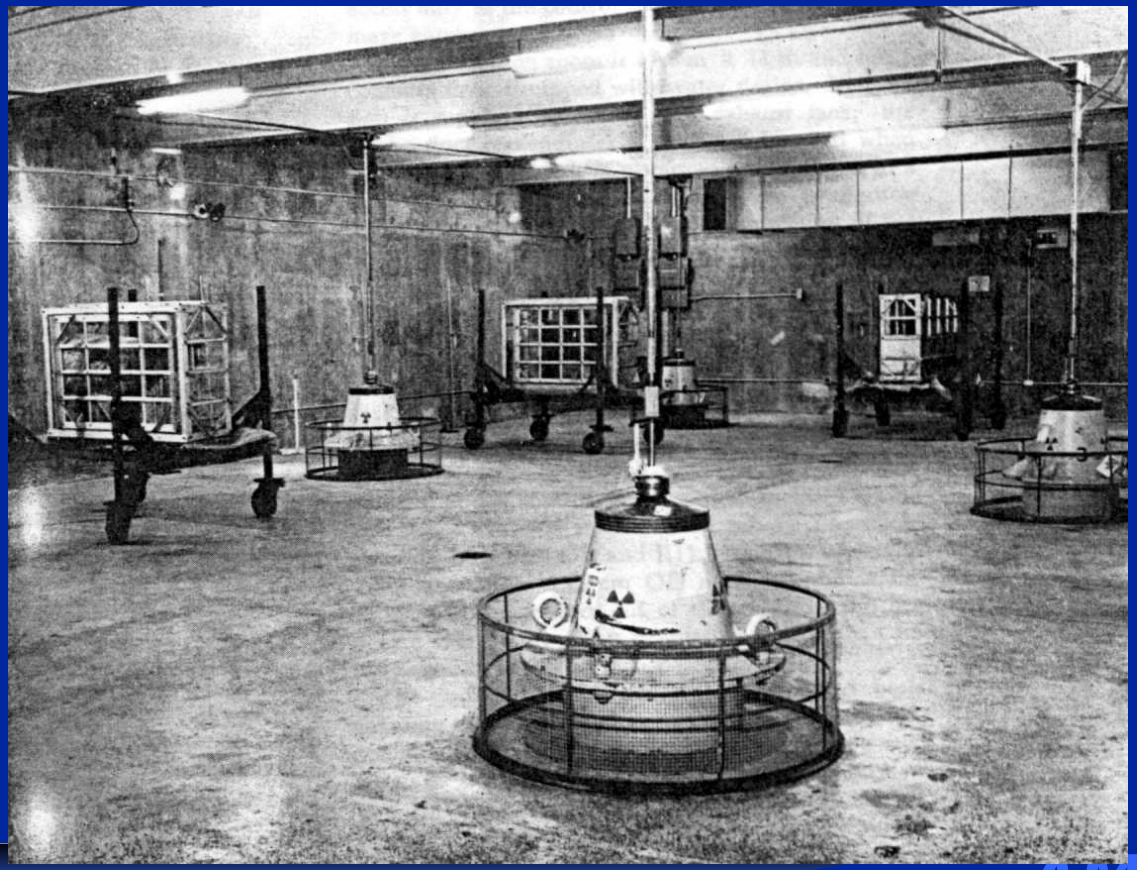
# Gamma Irradiators

- Radiation research





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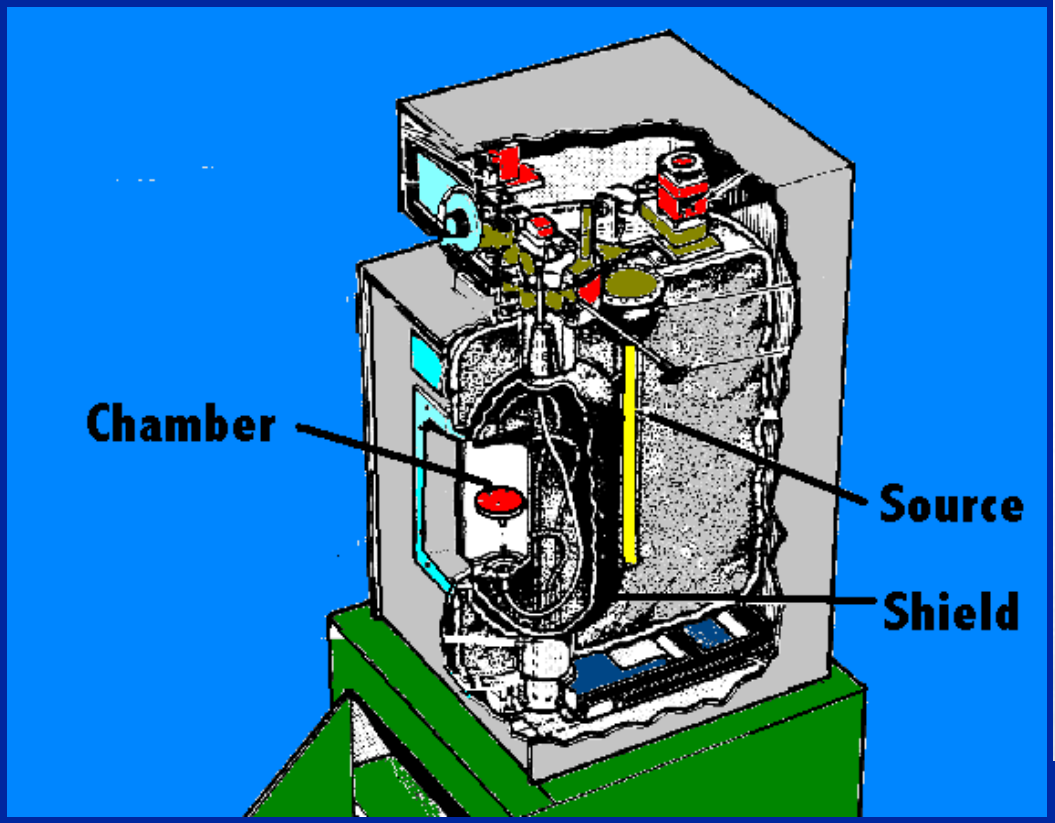
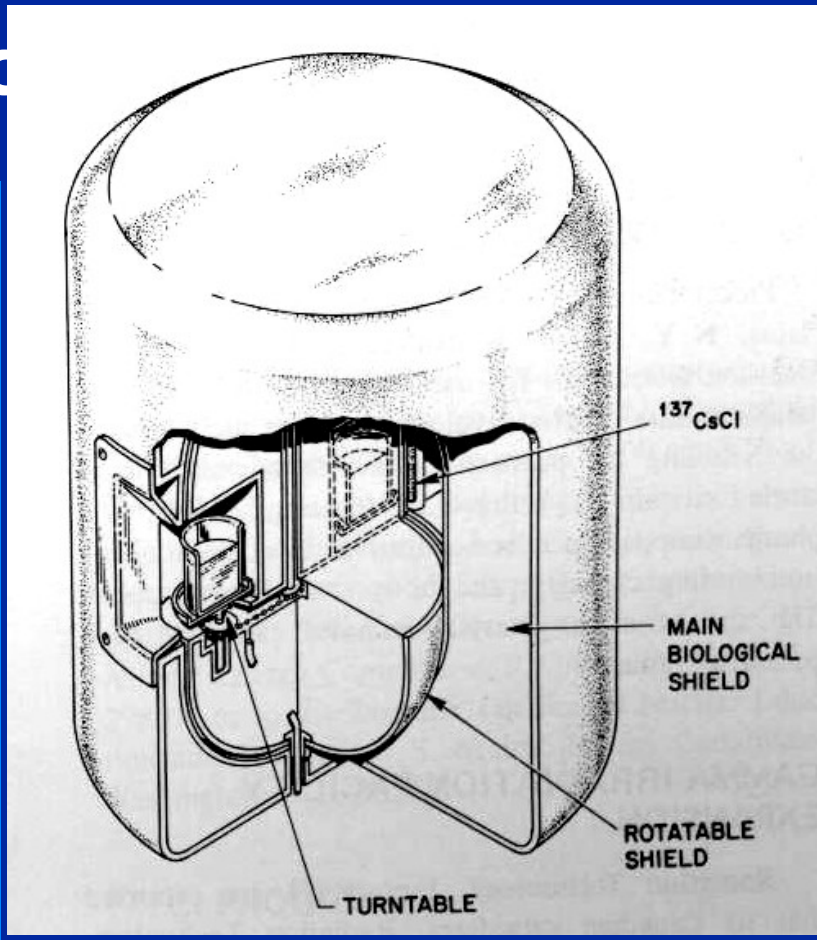
# Cabinet irradiators

- Agricultural researc



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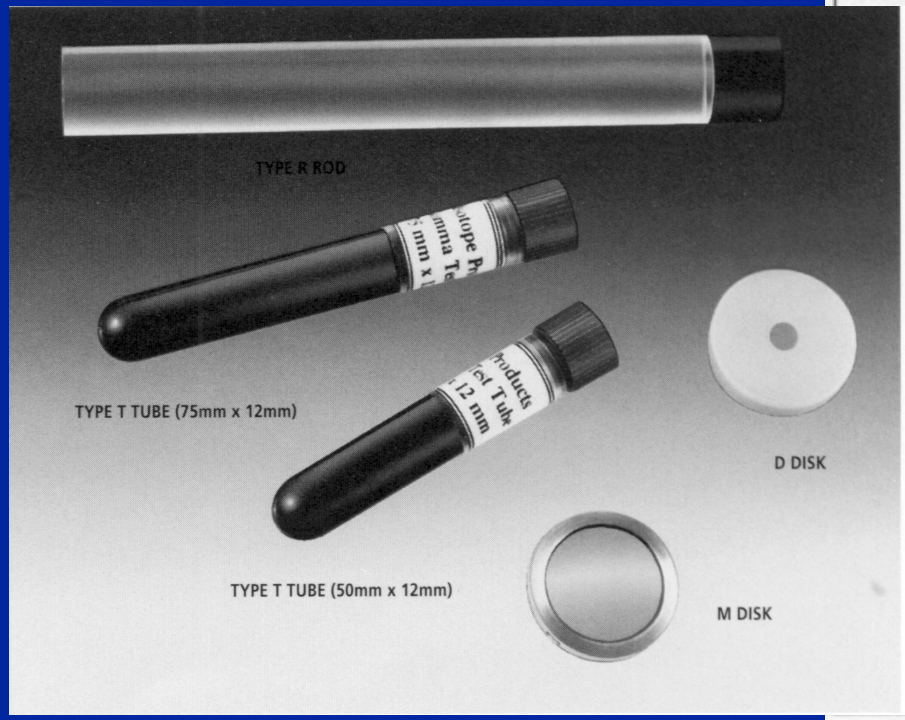
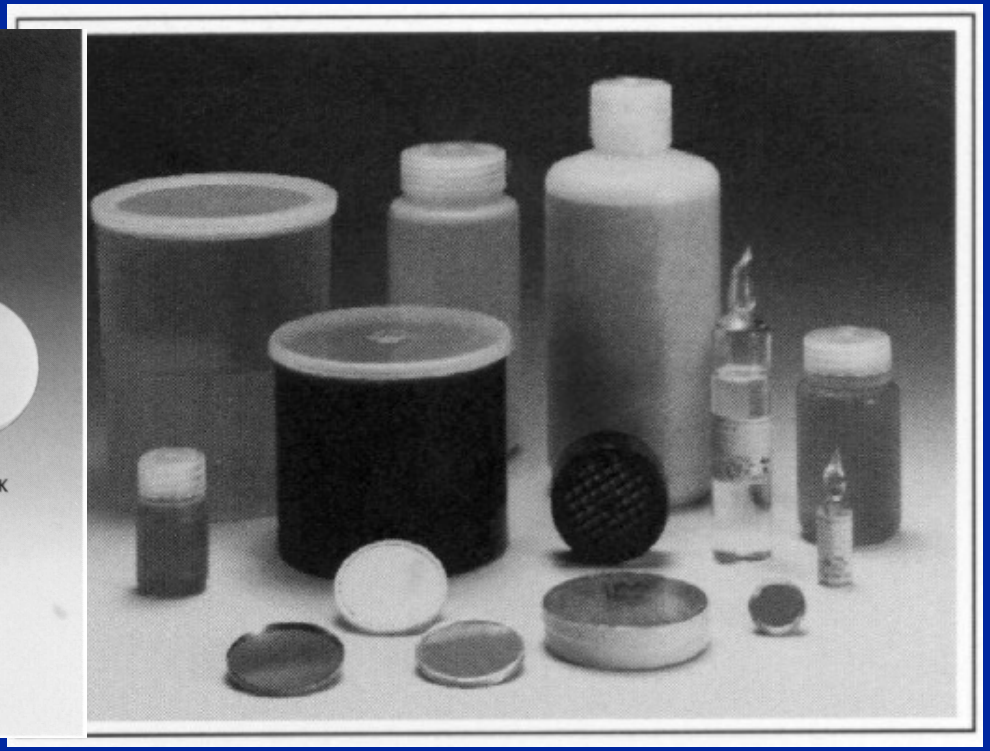
# Calibration Sources





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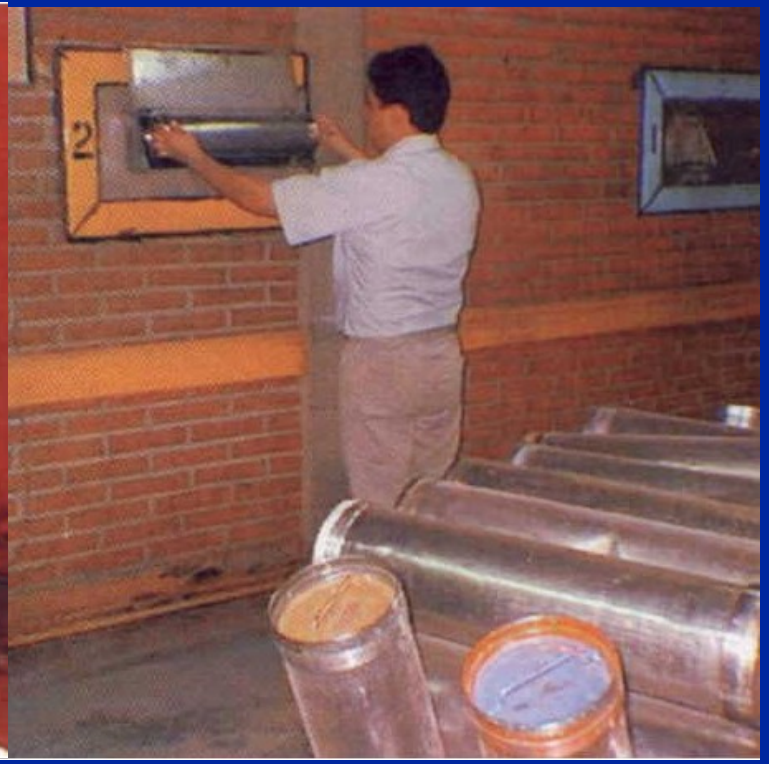
# Other Applications

# Insect Irradiators



# Consumer Devices

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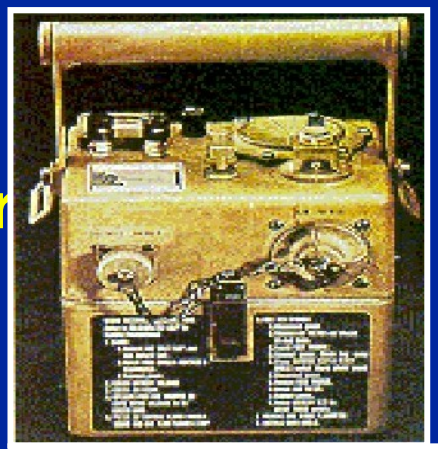
# M8A1 ACAA

M43A1 Detector

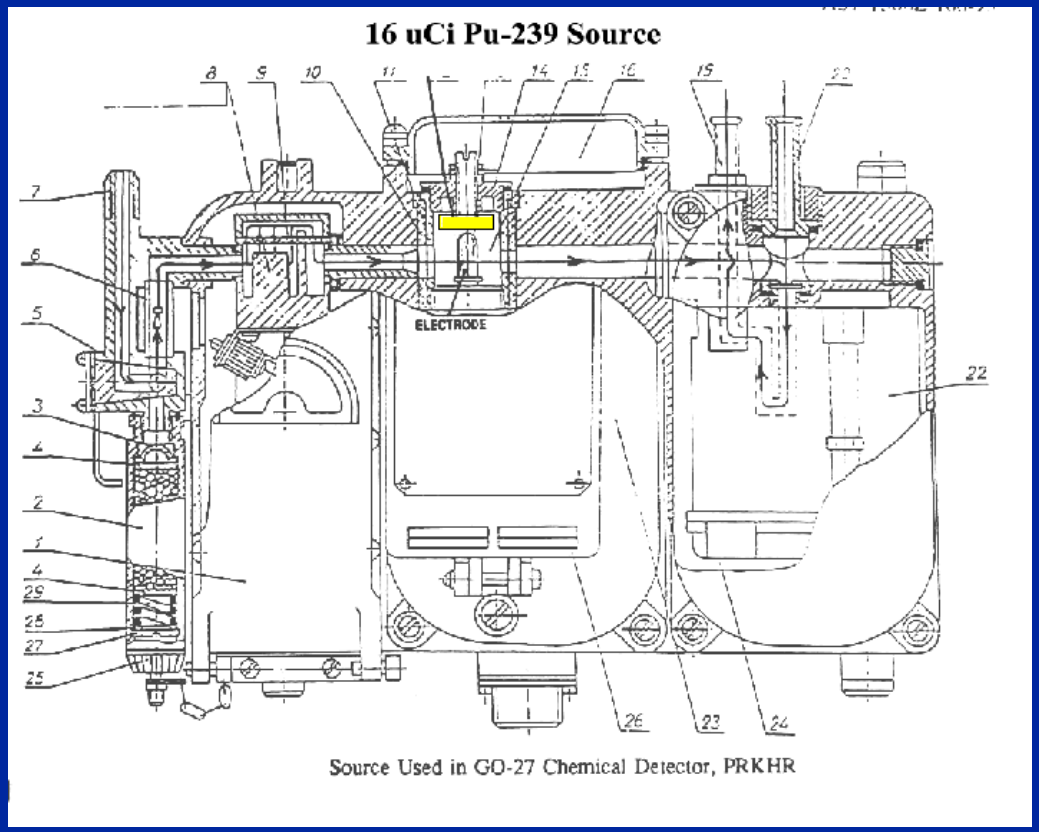


M42 Alarm

- Detects nerve agents
- Up to 5 alarms to 1 detector
- Comprised of the M43A1, M42 and WD1/TT telephone wire

# Chemical Agent Detectors

## Soviet GO-27 CAA



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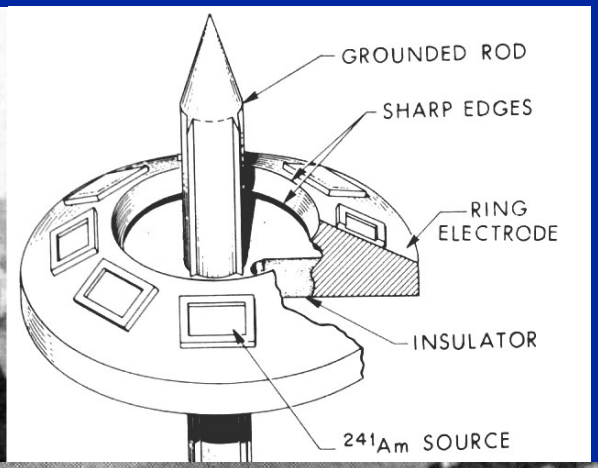
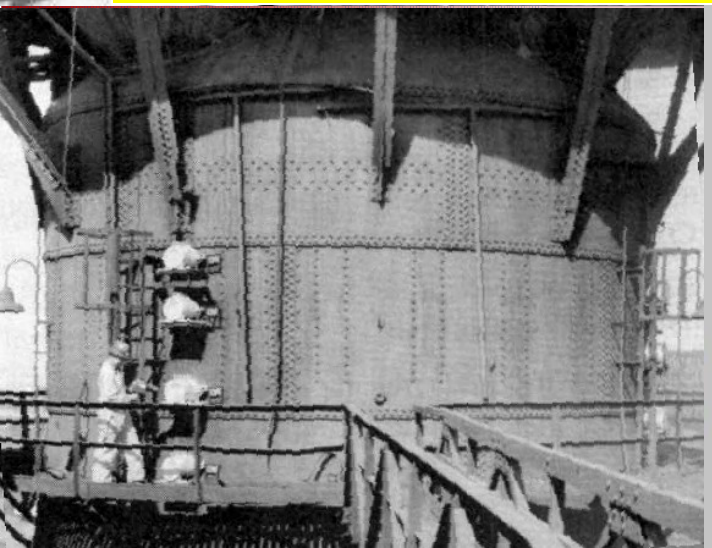
# Chemical Agent Detector

# Lightning Rods



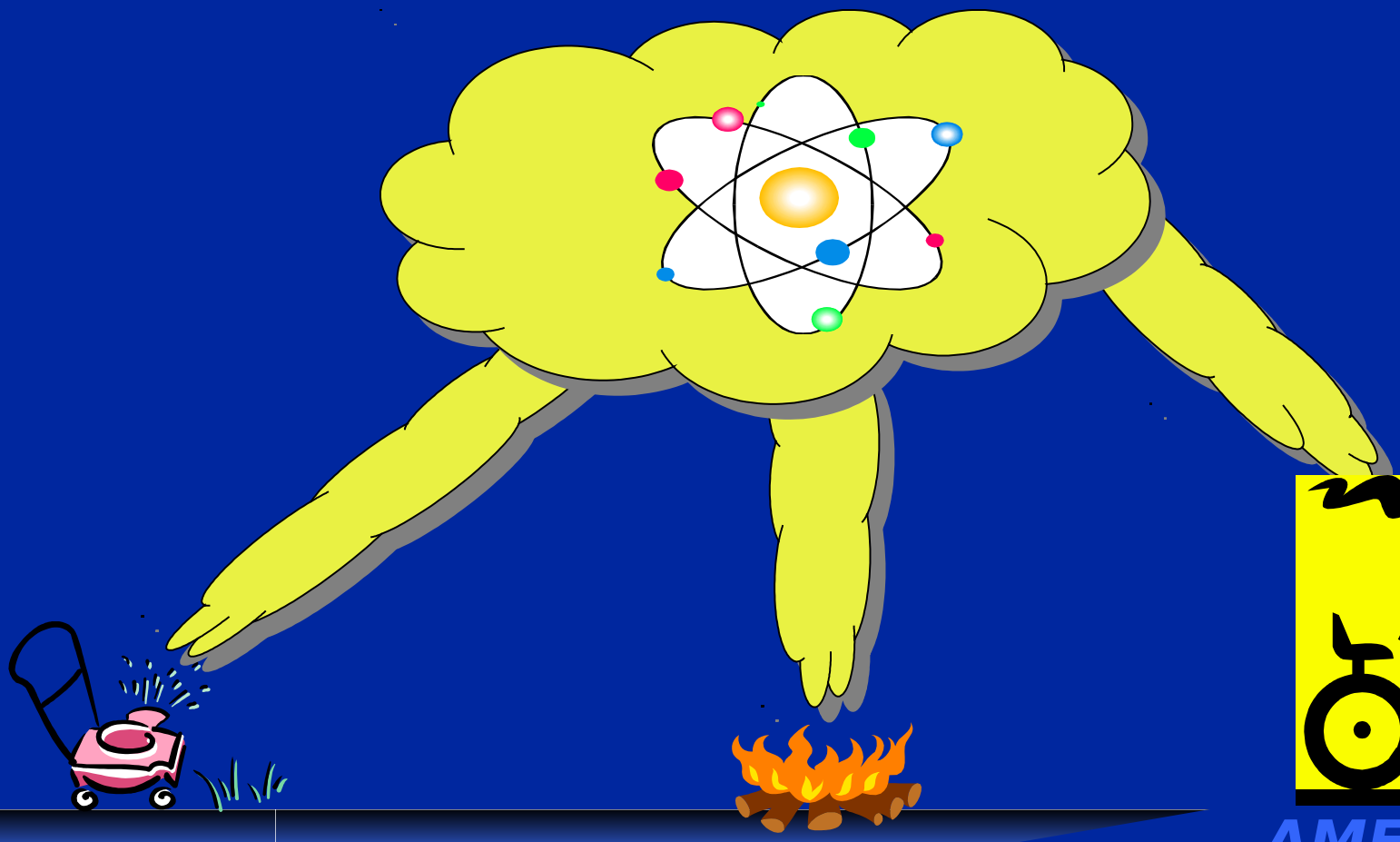
# *IAEA Estimates 500,000 Sources of Concern World-Wide (30,000 disused)*



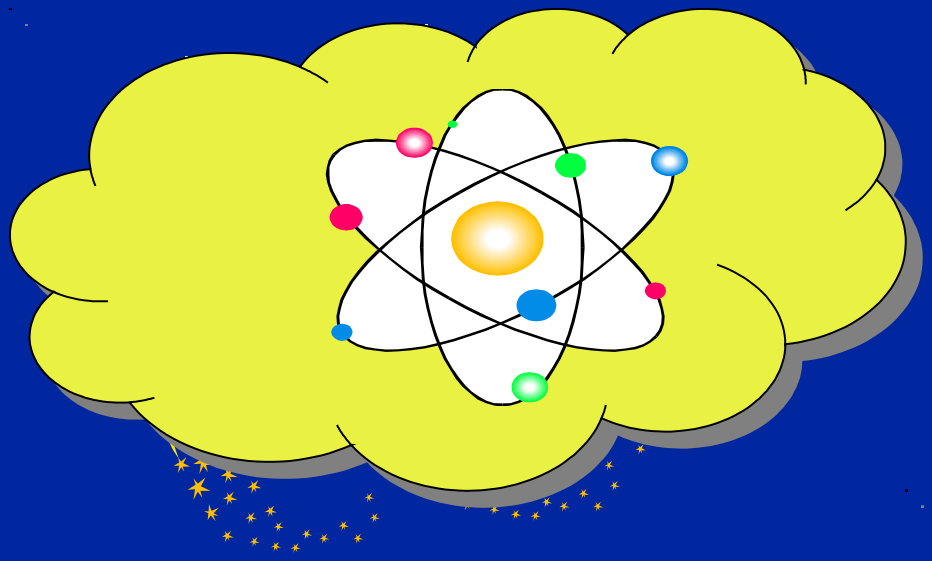
# Some Special Radiological Weapon Characteristics

- Radioactive material is indestructible
- People fear low-level exposures
- Contamination limits are low

# Radioactive material is indestructible



# Radioactive material is indestructible



# Low Level Radiological Threats

# Even "Harmless" Radiation Exposures Are Feared

- Every exposure increases risk of cancer
  - Exposures to children unacceptable
- Heightened public fears seen in many forums
  - Nuclear power
  - Radioactive waste
- Fears approach irrational
- Public fears reflected in regulations and contamination limits

# Army Doctrine Not Applicable

| | |
|---|---|
| RES 0 | No Exposure |
| RES 1 | 700 mGy (7 |
| RES 2 | 1500 mGy (150 rad) |
| RES 3 | >1500 mGy (150 rad) |

14x Occupational Lim

# Communicating Radiation

## Regulatory Limits

| |
|---|
| Public Limits |
| N |

## Physiological Effects

| |
|---|
| S |
| No Acute Effects |
| Minor Acute Effects |
| Injuries |

# Predicting Political Impact

| Designation |
| --- |
| Public Limits |
| Normal Occupational |
| Special Occupational |
| No Acute Effects |
| Minor Acute Effects |
| Injuries |

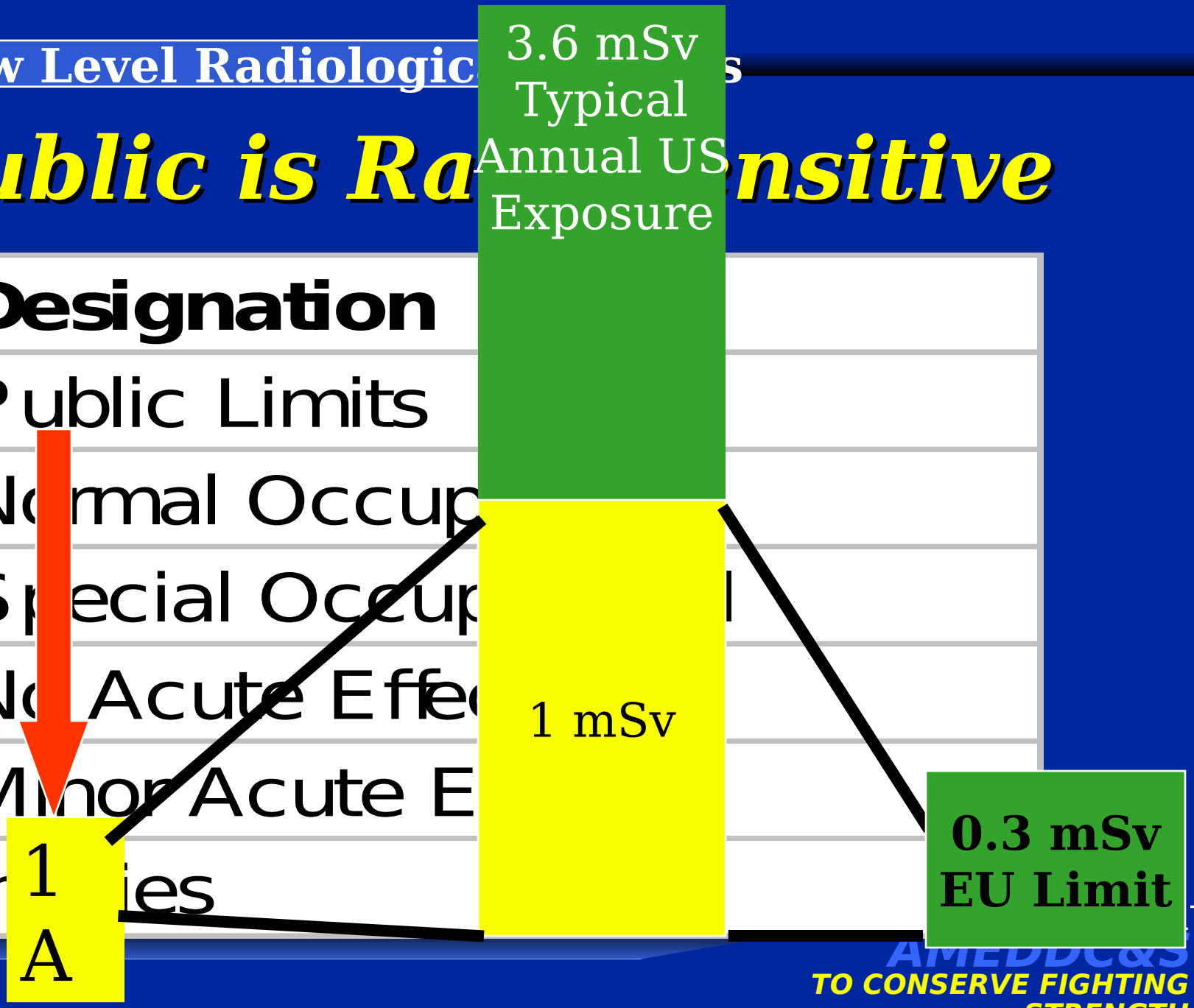
Mediur

High

## Low Level Radiologic s

# Public is Ra nsitive

| Designation |
| --- |
| Public Limits |
| Normal Occup |
| Special Occup l |
| No Acute Effe |
| Minor Acute E |
| Ir ies |



# Contamination Limits

**Typical Limit: 1,000 dpm/100 cm2**

**100 Ci Source**

44 km

**>2,000 km²**

44 km

# Sources Available to Any Actor

## *Attack Options?*

# Attack Methods

- External Exposure
  - Positioning where people pass near
- Internal Exposure
  - Poisoning food, water
  - Creating radioactive cloud
- Contact Exposure
  - Contaminating clothing, bedding, jewelry, etc.
- Combination Exposures: RDDs, dispersal



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# Attack Scenarios

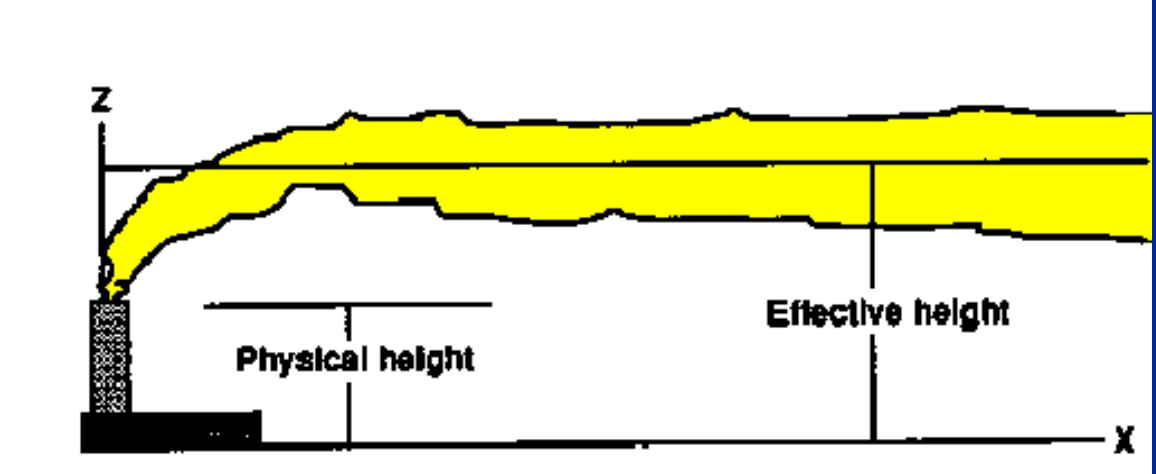
- Source positioned near a line (entrance to a dinning facility, exchange, etc.)
- “External Near” Scenario

# Attack Scenarios

- Source positioned along a road
- “External Far” Scenario

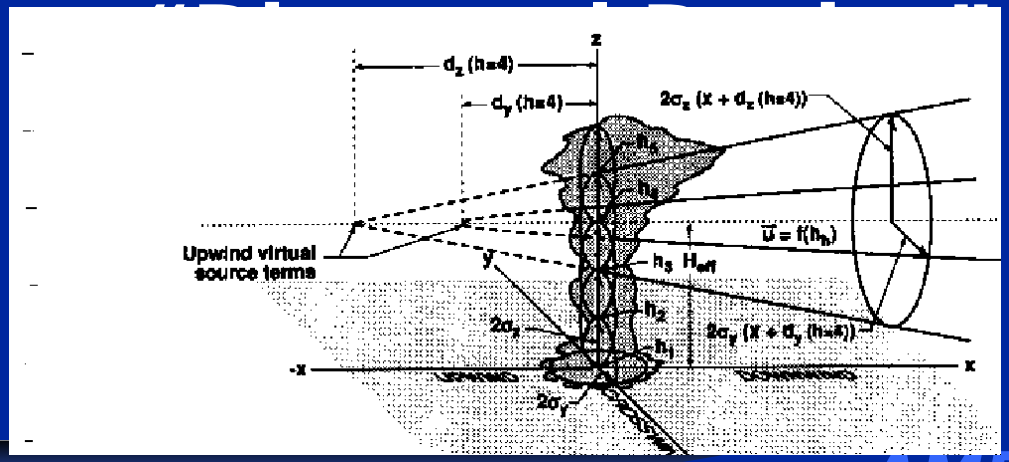
# Attack Scenarios

- Added to a furnace, the fuel of an internal combustion engine, or otherwise dispersed into the air.
- “Internal Plume” Scenario



# Attack Scenarios

- Material added to explosive
- Direct casualties plus a plume



# Attack Scenarios

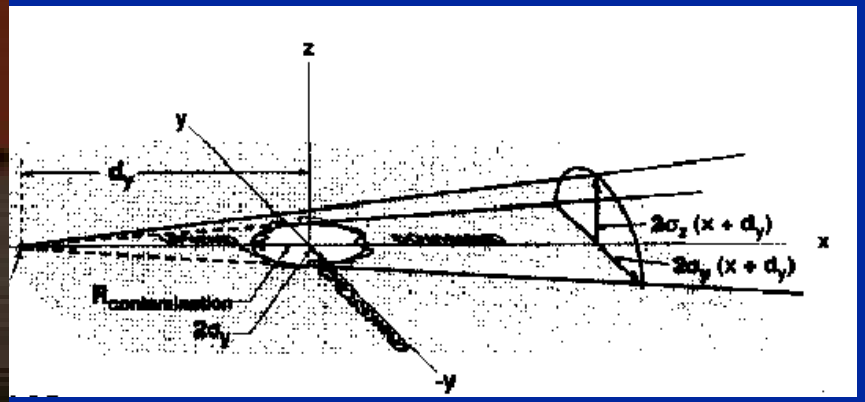
- Radioactive material added to food or drink

# Attack Scenarios

- Radioactive material spread on clothes, bedding,

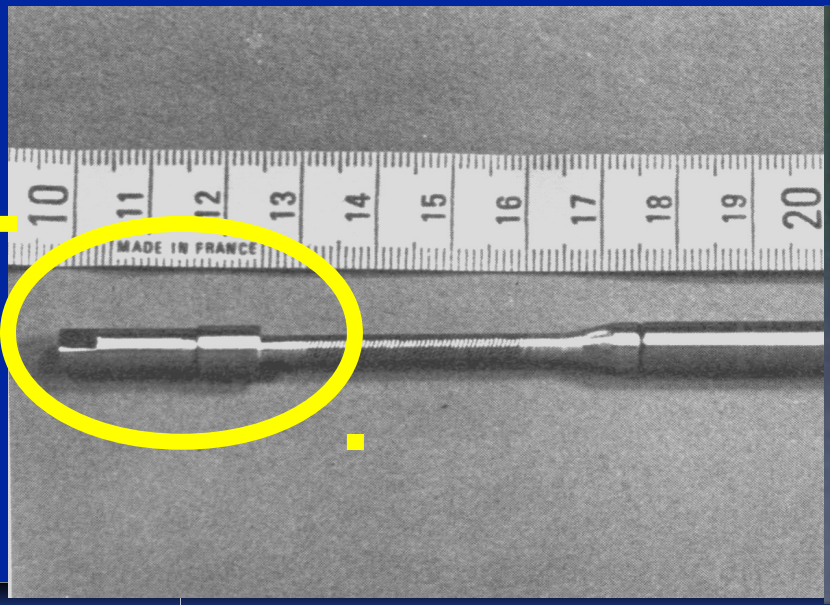
# Attack Scenarios

- Radioactive material spread on the ground



# A Hypothetical IRD Attack

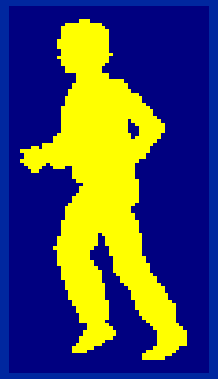
- Industrial radiography source (100 Ci Ir 192)
- Source dissolved in acid



# A Hypothetical IRD Attack

- Source & liquid spread on the ground in the line to a ride at a theme park

1-50 mS



# Attack is announced/discovered after 20 da

# A Hypothetical IRD Attack

- Injured or exposed >occupational limits: < 24
- Exposed >general public limits: ~100,000
  - i.e the “safe” limits
- Contamination:
  - throughout park/park’s transportation system
  - hotels, airports
  - even other states/countries

# Psychological Impact

- Of the 100,000 persons, a few additional cancer deaths expected
  - Note: 25,000 will develop cancer normally
  - How many deaths would be attributed to the attack?
- 1,000,000 (?) persons requiring shoes, automobiles or homes monitored ?
- Facility closed, 8 months? Longer?
  - Highest possible clean-up standards apply

# Radiological Weapon Threat

- Military radiological weapons
- Criticality devices
- Radiological Dispersal Devices (RDDs)
- Improvised Radiological Devices (IRDs)

**Political Tools**

# Radiological Weapon Threat

- Psychological Operations
  - 1995: Chechen rebels buried Cs-137 in Moscow park
  - 1996: Misinformation campaign concerning “nuclear waste dumping” in the Balkans
  - Nuclear fears (i.e. DU) exploited by Iraq, Bosnian Serbs, and Serbian government

# Conclusion

- Historical aspects of radiological weapons
- Radioactive sources
- Accident experience
- Types of radiological weapons
- Radiological terrorism threat

# Low Level Radiological Threats